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Insights on the structure and activity of Lusi mud edifice from land gravity monitoring.

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The Lusi mud eruption in East Java, Indonesia, active since May 2006, is a sedimentary-hosted hydrothermal system (SHHS) fed by magmatic fluids connected to the Arjuno-Welirang volcanic complex.
The aims of the present study are to investigate changes in the local gravity field to obtain new insight into: 1) the evolution of the collapse structure ten years after its inception, 2) provide new insights on the thickening of the mud edifice for constraints on 3D numerical models, and 3) the pulsating phases characterizing the Lusi activity, which result in temporal density variations of the mudflow inside the active conduit.
To investigate the structure of the mud edifice, we conducted a gravity spatial mapping over an area of 56 km2 with 390 new gravity stations. To investigate the density changes happening over time, we conducted several continuous gravity monitoring. We present results from gravity measurement collected during field campaigns in June and August 2016, and augmented by passive seismic and environmental parameter monitoring.
We calculated for a reference density of 2,670 kg m-3 a new Bouguer anomaly map, which shows significant changes in the local gravity field in comparison to the previously published 2006-gravity map. In the west and south part of the edifice, maximum gravity decreases (-1 mGal) characterize the collapse of part of the edifice. In the southeast and east of the central area of flooded mud breccia, the gravity field increases locally (+1 mGal) along the limit defined by a previous study on the surface deformation of the mud edifice. The 3D model supports the hypothesis of a locally pinched volume of either mud, sediment, or mix of both between the subsiding volume and the uplifting volume of mud.
The continuous gravity monitoring experiments were located at 320 and 380m away from the central area of a mud breccia flooded region. Over time, residual gravity variations reach up to 0.020 mGal in amplitude and occur at wavelengths ranging from 8.2 hours to 45.1 hours. Some very short gravity variation events, with durations of less than one hour, correlate with rapid change of atmospheric temperature and pressure, or stream temperature. Gravity variations over time cross-correlate well with the duration increase of seismic events. In addition, from our 3D forward model, within the conduit feeding each active vent, the mud density variations range between 100 and 775 kg m-3. Even at distances of 320 to 460m from the eruptive vents, this study shows that gravity monitoring and atmospheric pressure monitoring are potentially valuable tools for monitoring and gaining insight into processes occurring in the feeder conduit of a mud eruption.
We show that gravity method is an efficient method to monitor the evolution of an active mud edifice by bringing new insight on the mud edifice structures, and over time on the density change, which is associated to changes in the eruption dynamics.